

i .	$(B_i)^2/C_i + [i, 0]$.	Ratio of each term to the next.
2	-0·000080868	—
4	0·000247274	3·9
6	0·000062350	3·2
8	0·000019576	3·1
10	0·000006328	—

We may conjecture that the uncomputed residue is about 0·000003.* The convergence is clearly slower than in the case of Jacobi's ellipsoid, but I cannot think that the series can converge so slowly as to justify M. Liapounoff.

It seems to me, then, that this present investigation should lead us to look with doubt on an argument adverse to the former conclusion.

On the Wave-lengths of Lines in the Secondary Spectrum of Hydrogen.

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The spectrum of hydrogen is one which has engaged the attention of numerous observers from the year 1851 onwards. Historically it is of great interest, firstly owing to the part it played in the controversy between Ångström and Wüllner on the plurality of spectra, and secondly, because it was the first spectrum in which a relation between the wave-lengths of the lines composing it was discovered.

It is not proposed to discuss the origin of the two hydrogen spectra in this communication, as it has recently been done in a very complete manner by Dufour;† the main points at issue, however, may perhaps be briefly stated.

Wüllner,‡ who was the first to make detailed observations of the spectra of hydrogen under different conditions, described three spectra. The first consisted of three bright lines, the second of a number of bands, and the third of several bright lines mostly in the green. This was disputed by

* The absolute magnitudes of the numbers in the series compared are very different, but this merely depends on the definitions chosen for the several harmonic functions.

† 'Ann. Chim. Phys.' (8), vol. 9, pp. 361—432, 1906.

‡ 'Phil. Mag.' (4), vol. 37, p. 405, 1869, and vol. 39, p. 365, 1870.

Ångström,* who maintained that one substance could have only one spectrum. Hasselberg,† however, showed that though Wüllner's third spectrum was due to impurity, yet the other two could always be obtained from one sample of hydrogen, their relative intensities alone varying. The results of numerous investigations following this early work have given rise to two hypotheses: firstly, that the primary spectrum is due to atomic, and the secondary to molecular, hydrogen, and secondly, that the primary spectrum arises from the presence of water vapour. Some observers also maintain that the secondary spectrum is due to impurities. The above-mentioned paper by Dufour, however, seems to point very definitely to the correctness of the first hypothesis mentioned, inasmuch as he found that hydrogen prepared by several different methods and purified by diffusion through a hot platinum membrane gave the same spectrum in vacuum tubes of glass, silica, and fused boron trioxide. In all cases, both the primary or stellar spectrum, and the secondary spectrum were seen. Observations were also made at atmospheric pressure by means of an arc between electrodes of various carefully purified metals. The results were the same as before, even when the tube was cooled in liquid air. The primary spectrum alone was produced in an atmosphere of water vapour, but was also found in a tube of dry hydrogen which had been standing in contact with phosphorus pentoxide for a long time, and hence the spectrum is not due solely to water vapour. Other experiments upon the effects produced on the spectrum by a magnetic field, and the introduction of condensers into the circuit, led to the same conclusion, viz., that the primary spectrum is due to atomic, and the secondary to molecular, hydrogen.

The above brief abstract will show the stage which has now been reached by experimental work on the origin of the two hydrogen spectra, and though we are not definitely able to assert that the conclusions drawn are correct, yet the data on the subject are extensive and sufficiently complete.

When, however, we look upon the spectrum of hydrogen from another point of view, namely, that of the wave-lengths of the lines comprising it, it will at once be seen that the same completeness does not exist. The lines of the primary spectrum have, it is true, been measured with accuracy by Ames,‡ and Evershed,§ but it must be remembered that, in spite of their importance owing to the relation between their wave-lengths discovered by Balmer,|| the number so far seen is only 29, and, of these, two-thirds occur

* 'Pogg. Ann.,' vol. 144, p. 300, 1871, and 'Comptes Rendus,' vol. 73, p. 368, 1871.

† 'Bull. Acad. Imp. St. Petersb.,' vol. 27, p. 97, 1881.

‡ 'Phil. Mag.,' vol. 30, p. 33, 1890.

§ 'Phil. Trans.,' A, vol. 197, p. 381, 1901, and vol. 201, p. 457, 1903.

|| 'Wied. Ann.,' vol. 25, p. 80, 1885.

only in stellar spectra. Moreover, the intensity of nearly all of them is very small when compared with that of many of the secondary lines seen in an ordinary hydrogen vacuum tube, so that in order to eliminate hydrogen from a spectrum, it is equally important to know the wave-lengths of the secondary lines.

The classical research of Hasselberg,* which has given us the most complete list of wave-lengths of the hydrogen lines we possess, is not sufficiently accurate for modern requirements, especially in the red portion of the spectrum. In the first place, the scale upon which the wave-lengths are based is that of Ångström, and, in the second place, it is pointed out by Hasselberg himself that the effect of temperature changes was very great, and difficult to eliminate, two prisms of carbon disulphide having been used as the dispersive medium. However, as will be seen from the following table, the results are remarkably near to those obtained by more refined apparatus.

The only other available measurements are those of Ames,† who gives 61 of the chief secondary lines between the green and ultra-violet regions, and of Frost,‡ who determined the wave-lengths of 90 lines between $\lambda 4725$ and $\lambda 4358$, the source being a helium tube which developed the hydrogen spectrum. These measurements could not be continued owing to the tube running out. In addition, Dufour gives a list of the wave-lengths of 125 lines from $\lambda 4935$ to $\lambda 3652$, but these determinations were made by means of a grating without a slit, and are only accurate to half an Ångström unit.

This want of data first attracted my attention when measuring the spectrum of the lighter constituents of the atmosphere,§ which consisted partly of hydrogen. When working with the rare atmospheric gases it is very difficult to remove hydrogen from the electrodes of vacuum tubes, and, moreover, there are cases in which it may be of advantage to have hydrogen present, in order to use its lines as standards. Consequently, it is highly desirable that the wave-lengths of all the brightest lines in the secondary spectrum should be known as accurately as possible.

With this end in view, the following experiments were made. The gas to be examined was contained in a vacuum tube with aluminium electrodes, and having a quartz plate sealed on opposite the end of the capillary portion.

* 'Mem. Acad. Imp. St. Petersb.,' vol. 31, p. 14, 1883, and 'Bull. Acad. Imp.,' vol. 30, p. 14, 1886.

† *Loc. cit.*

‡ 'Astrophys. Journ.,' vol. 16, p. 100, 1902.

§ 'Roy. Soc. Proc.,' A, vol. 80, p. 181, 1908.

In one case no hydrogen was put in the tube, but a new electrode was used, and the tube filled with moist air. It was then pumped empty and a current passed. A large quantity of hydrogen was produced, which was pumped off until the tube became phosphorescent. The direction of the current was reversed, and thereby causing a further evolution of hydrogen. After three exhaustions the tube was sealed off, and it was found that on running for a few hours the quantity of gas did not appreciably increase. When a series of photographs had been taken with this tube it was evacuated and filled with dry hydrogen made from palladium hydrogen, the pressure being about 1 mm. At greater pressures the brilliancy diminished. The two series of spectra obtained in this way were very similar, but the first one contained a considerably larger number of lines than the other. These additional lines were always very weak, and could not be attributed to impurities, so that it seems probable that they were merely made visible because of the slightly greater brilliancy of the first tube used, and no distinction is drawn between them and the others in the following table. One plate, however, was obtained which showed a number of not very weak lines in the extreme ultra-violet, and several of these appear to be identical with the stronger lines occurring in the spectrum of the oxyhydrogen flame given by Liveing and Dewar.* I was unable to obtain them again.

The secondary spectrum of hydrogen consists of two parts, the first being composed of a large number of lines, which are nearly all sharply defined, and which are particularly intense in the orange and violet regions. Although plates were used which were sensitive as far as $\lambda 8000$, no lines could be detected on the less refrangible side of the C line; but, on the other hand, a considerable number were measured the wave-lengths of which were less than $\lambda 3646$, the theoretical limit of the primary spectrum according to Balmer's formula. It is possible, however, that owing to the correspondence with Liveing and Dewar's values just mentioned, the majority of these arise from the presence of water vapour. The second part of the spectrum appears to be continuous, and extends from about $\lambda 4570$ to the extreme ultra-violet.

The lines of the primary spectrum were not especially brilliant, the intensity of the F line being about equal to, but certainly no greater than, that of the stronger secondary lines. Only eight primary lines could be seen at all, whereas Ames was able to measure 13.

The tubes always contained mercury vapour, which was only very slowly absorbed by the electrodes, so that mercury lines were obtained on all the photographs, and the colour of the incandescent gas was a pale pink.

* 'Phil. Trans.,' A, vol. 179, p. 27, 1888.

A current from an induction coil without a Leyden jar was used to illuminate the tubes, and exposures of 16 hours were given. This was not really sufficient, as many of the weaker lines were hardly visible, and very difficult to measure, but it was found that not much advantage was to be gained by increasing the exposure beyond this time, as the temperature changes and vibration were apt to produce a blurred image. All the measurements were made in the first order of the Rowland Concave Grating at University College, the focal length of which is 10 feet, and which is ruled with 14,438 lines to the inch. A quartz condensing lens was used to focus the image of the capillary part of the tube on to the slit, and an iron arc spectrum was photographed on each plate above the hydrogen.

Wratten Panchromatic plates, 25 cm. long, were used, except when photographing beyond the C line, in which case Spectrum plates were employed.

Both the hydrogen and principal iron lines were measured twice on each plate, and the wave-lengths of the latter calculated. The differences of the values obtained in this way from the known iron wave-lengths were then plotted against the micrometer readings, and a curve thus obtained by means of which the wave-lengths of the hydrogen lines could be corrected for errors arising from the screw, etc. At first, the wave-lengths of the iron lines given by Kayser and Runge* were used as standards. But it was found that they were not sufficiently accurate, and finally, only the standard iron lines, given by Kayser,† and some of Rowland's standards were employed. In several cases where the correction was not quite certain both the spectra were remeasured on a different part of the screw.

No attempt was made to determine the absolute wave-lengths of the hydrogen lines from those of the iron lines because of the probability of a lateral shift between the two spectra, but lines in the gas spectrum were themselves used as standards, those chosen for the purpose being three primary hydrogen lines, and the yellow and green mercury lines. From these, the wave-lengths of some second order mercury lines were determined, and used as standards in the ultra-violet.

The values adopted for the wave-lengths of these standard lines were:—

6563 ·05	3654 ·96
5790 ·86	3650 ·28
5769 ·80	3131 ·94
5460 ·93	3125 ·78
4861 ·50	2655 ·26
4358 ·49	2653 ·83
4101 ·90	

* Watts, 'Index of Spectra,' App. C, p. 1, 1888.

† 'Hand. der Spectroscopie,' vol. 1, p. 726.

The C and F lines are Rowland's standard values, and the figure for H is the one recently given by Evershed.* Some difficulty was experienced in obtaining reliable values for the yellow mercury lines, as those given by Kayser and Runge† differed by more than 0.3 Å.U. from the values actually obtained. Consequently, a redetermination of the wave-lengths of these lines was undertaken, a mercury lamp being used as the source of light, and the preliminary results confirmed those previously obtained with the hydrogen tubes. However, before the investigation was completed, the required values were found in a paper by Hartmann,‡ in which the determinations of Fabry and Perot of the wave-lengths of the four chief mercury lines were reduced to Rowland's scale, and these values were consequently adopted. The lines 3654 and 3650 are given by Ames,§ with whose values mine agree very closely, and the last four lines on the list were measured in the second order. It must be borne in mind, however, that these so-called standards were really more of the nature of checks upon the values obtained. Actually all the wave-lengths were calculated from those of the C and F lines by means of the iron standards, and it was only necessary to introduce a slight additional correction amounting at most to 0.04 Å.U. in order to obtain the most exact values.

The error in the measurements is difficult to estimate. The numbers given in the table are, for the most part, the mean of three values obtained from three different plates, weighted according to the distinctness of the line on the plate, although, as before mentioned, many of the very weak lines could only be seen on one plate, and in consequence, the liability to error of such is considerably greater than that of other lines. Each plate was measured twice, the readings of one line rarely differing by more than 0.01 mm., corresponding to 0.05 Å.U., and the agreement between numbers given by different plates being fairly good. This correspondence really gives the best idea of the errors. Their extent may be seen from the following table, which

6	55	56	57	2	19	22	22
2	60	59	55	1	92	98	98
2	52	56	49	1	88	91	89
10	01	01	01	1	55	56	52
3	44	48	46	0	26	32	?
4	22	22	20	0	46	48	54
3	18	15	15	1	56	57	61
9	03	05	01	0	06	11	13
0	28	26	36	3	26	26	26
1	61	68	69	1	27	32	22

* 'Astrophys. Journ.,' vol. 28, p. 162, 1908.

† Watts, 'Index of Spectra,' App. D, p. 17, 1891.

‡ 'Astrophys. Journ.,' vol. 18, pp. 167-190, 1903.

shows the decimal parts of 20 consecutive lines chosen at random. The numbers in the first column denote the relative intensities, and it will be seen that the very weak lines are much more liable to error than the others.

The only line which caused difficulty owing to its strength was the C line, but its position was accurately determined by taking a number of readings.

Table I gives a list of the lines measured, together with their relative intensities. For the sake of comparison, Hasselberg's values are also given, but as they were on Ångström's scale, the corrections given in Watts' 'Index of Spectra,' App. B, p. 1, have been applied to reduce them to Rowland's standard. The second place of decimals has, however, not been altered owing to the uncertainty of the amount of such alteration. Hasselberg's intensities have also been ranged from 0 to 10 instead of from 1 to 6.

It will be noticed that Hasselberg gives a considerable number of lines in the yellow-green region which I have not observed. It seems probable that as his measurements in this part of the spectrum were visual, and the eye has a maximum of sensitiveness in this place, these additional lines were too weak to be recorded photographically, and, indeed, indications of several lines can be seen which are too weak to measure. It may be, however, that, in view of the way in which the intensities of different parts of the secondary spectrum vary, Hasselberg's tubes were of such dimensions, and were filled at such pressures, that the yellow portion of the spectrum was brighter than in my experiments.

In the table, the values of Frost and Ames are included, and it will be seen that the agreement is very close.

Table II gives a list of the principal mercury lines which were measured, the values being deduced from photographs in both the first and second orders. The figures are very near those of Ames, and hence are probably rather more accurate than those of Kayser and Runge, in spite of the "limit of error" given by these observers.

It will also be noticed that the intensities differ considerably from those previously published, a possible explanation being that my values were obtained for a mixture of mercury vapour and hydrogen.

In conclusion, I should like to take this opportunity of offering my best thanks to Sir William Ramsay for supplying me with a sample of pure hydrogen, and for the constant interest he has taken in this work.

Table I.

Wave-length.	Intensity.	Hasselberg.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.
<i>6563·05*</i>	50†			6159·82	0	59·68	1
6527·63	1			6155·86	0	56·04	2
6517·99	1			6153·48	0	53·75	1
6506·82	1			6151·83	0	51·84	1
6475·70	0					46·80	1
6473·92	0			6144·29	0	44·43	1
6441·83	0			6143·30	0	41·78?	0
6438·10	0			6139·72	0	39·90	0
6435·02	0			6135·56	6	35·45	10
6433·80	0			6134·58	2		
6429·57	0			6132·06	0		
6428·36	2	23·67	1	6127·53	2	27·51	6
6412·96	0			6122·01	10	21·88	10
6402·51	1					19·32	1
6399·71	1	95·32	1	6109·81	0	12·94	0
6383·20	0			6108·19	0	08·53	0
6380·30	0			6098·45	3	98·66	2
6377·59	0			6097·57	0		
6372·41	0			6096·21	4	96·20	6
6365·07	0					94·00	6
6362·67	1	59·54	0	6091·16	3	91·00	5
6340·75	2	38·60	1			84·85	0
6335·53	0			6080·03	9	81·10	8
6332·70	1			6079·28	0	79·51	0
6329·84	0d‡			6074·66	1	74·92	4
6327·25	8	24·87	6	6070·21	2	70·66	8
6320·64	0			6067·96	1	67·92	4
6303·68	0	01·75	1	6066·89	1		
6302·46	0			6063·54	1	63·98	4
6299·60	5	97·90	5	6056·28	0	56·67	1
6285·56	4	84·39	4	6053·49	0		
6277·30	1			6052·58	1	53·06	6
6275·10	2	74·00	0	6048·10	0	48·24	3
6271·55	2	70·63	0	6045·80	0	45·44	1
6268·20	0			6044·80	0	43·30	1
6249·42	0			6041·27	1	41·23	1
6240·42	0			6032·14	5d	32·07	10
6238·57	6	38·26	5	6030·30	0d		
6236·03	0			6028·21	6	28·21	6
6233·22	1	33·09	0	6024·00	4	23·87	5
6230·48	2			6021·53	4	21·43	6
6225·02	10	24·86	6	6018·53	9	18·46	10
6221·99	0			6012·82	0		
6201·38	2	01·66	1	6011·72	0	12·02	0
6199·58	4	99·57	6	6007·27	0	07·40	0
6198·11	0			6005·19	0	05·24	0
6197·32	2	97·04	4	6003·08	4	03·25	5
6183·19	4	83·09	6	5998·19	0	98·28	0
6176·40	0	76·57	2	5994·30	4	94·64	4
6175·14	0			5992·14	0d	92·85	4
6174·28	1	74·57	5	5990·79	1	90·81	3
6169·85	1	70·46	3	5989·47	3	89·32	4
6167·92	0	68·07	0	5982·79	3	83·07	6
6164·41	0	64·95	2	5975·68	8	75·77	8
6162·63	0			5974·45	1		
6161·81	1	62·22	5	5970·49	1	70·15	4

* Ames, 6563·04.

† The lines of the primary spectrum are printed in italics.

‡ d signifies that the line is diffuse.

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.
5967·55	1	67·57	5	5796·82	0	96·07	0
5963·70	1	63·62	4	5794·94	1	94·23	2
5959·98	3	60·00	5	5791·93	2	91·42	2
5956·64	0	56·47	0	5788·50	1	87·22	0
5950·15	6	50·15	6	5786·00	3	85·39	6
5947·56	2	47·80	5	5783·32	0		
5943·65	0	43·86	0	5780·24	0		
5942·24	0	42·15	0	5779·22	0	79·12	4
5938·87	6	38·91	8	5775·28	2	74·85	6
5936·29	1	36·36	0	5773·48	1	73·02	0
5931·62	6	31·77	8	5766·26	0	66·42	3
5926·14	0	28·48	0	5763·60	0		
5925·09	2	25·17	6	5763·01	0	62·94	0
5920·95	2 <i>d</i>	21·09	6	5760·58	1	60·35	5
5918·37	0			5759·76	1		
5916·76	1	16·60	6	5757·57	1	57·42	5
5916·31	1			5755·96	0		
		12·32	0	5742·05	0		
5909·71	0	10·02	3	5740·15	0	40·55	0
		05·66	0	5738·48	0	38·90	0
5903·77	0	04·06	1	5737·06	3	35·77	6
5900·92	0	00·97	1	5735·37	1	34·30	1
		98·50	0	5732·11	2	30·85	6
5896·21	0	96·41	0	5728·76	2	27·56	6
5894·24	0	94·36	1	5723·63	0	22·63	0
5891·55	0	92·15	0	5716·31	0	15·17	1
5890·19	2			5713·59	1	12·83	2
5889·29	2			5709·93	0	09·14	0
5888·41	3	88·87	10	5703·50	0	08·25	4
5884·91	2	84·52	10	5700·84	0	00·34	1
5884·18	2			5697·76	0	97·09	1
5882·17	0			5694·35	0	93·97	1
5879·55	1	79·08	6	5689·43	2 <i>d</i>	89·10	6
5878·73	2			5684·33	0	84·09	5
5876·35	0	76·45	0			82·64	5
5872·12	2 <i>d</i>	72·38	6			76·36	0
5870·30	0					74·62	0
5869·47	2	69·76	6			72·88	2
5864·74	1	64·91	2	5671·10	0	70·70	2
5861·77	0	62·01	1			67·37	2
5859·96	1	60·32	0			63·46	0
5857·40	0	57·67	0	5661·97	0	61·80	3
5852·72	6	51·96	2			59·57	2
5849·56	2	49·61	2			57·66	2
		47·84	0	5655·98	1	55·61	4
5836·28	5	36·45	6			52·50	1
5833·18	2 <i>d</i>	33·34	3	5647·87	0	47·41	0
5831·27	1	31·53	3			46·17	0
5824·64	0	25·00	0			42·54	4
5822·99	3	23·00	5	5635·05	0	34·43	4
5822·28	1					31·97	0
5819·58	1	19·82	4			30·30	3
5816·70	1	17·10	0			26·80	3
5815·18	2	15·48	4			23·89	0
5812·82	5	13·00	10			22·24	0
5811·74	1			5621·09	0	20·05	1
5806·35	2	05·40	1			16·33	0
		04·00	0	5612·77	1	11·80	6
5801·45	0	00·82	1			08·94	0
5799·25	0	98·70	0			03·56	2

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.
5600·65	0	99·65	4	5319·32	0	20·50	0
5597·80	1	96·75	5	5318·06	0	18·18	2
		91·35	1			14·08	0
		79·43	1			09·28	2
		74·21	1	5303·35	2	03·54	6
		72·35	1	5291·79	1	91·78	4
		64·61	0	5284·65	0	84·64	3
		61·95	0			78·78	0
		55·14	1	5272·48	2	73·00	4
5552·60	0	52·55	3	5270·63	0		
		47·77	0	5266·22	2	66·78	4
5543·71	0	43·36	3			64·65	4
5537·67	3	37·40	6	5261·34	1	61·94	2
		33·84	0	5256·78	1	57·23	2
		30·04	0			38·36	2
		26·98	1			31·30	0
		24·04	0	5229·79	0	29·05	2
		21·52	0	5226·90	0	26·43	2
		18·24	3	5224·52	0		
		15·32	0			22·66	2
		07·78	0			20·73	0
5505·79	2	05·50	6			14·67	2
5499·84	1	99·45	6			05·39	0
5496·23	0	95·79	4			02·93	0
		94·07	0			99·93	2
5481·31	2	80·94	6	5196·55	1	96·90	5
5475·08	0	74·71	1	5193·72	0		
		71·54	0			91·09	0
		65·20	0			88·55	0
		57·08	0	5180·93	0	81·14	2
		54·86	0	5174·98	0	75·16	2
		52·35	1			71·78	0
		46·75	0			68·99	0
5438·06	0	39·88	0			65·49	0
5435·06	1d	34·83	5			57·15	0
		30·96	0			54·76	2
		28·84	0	5149·10	0	47·28	3
5426·20	1	26·00	5	5143·68	0	43·64	3
5420·10	4	20·03	6			37·45	0
5418·05	0	18·36	1			34·46	0
		10·26	0			32·34	0
5409·02	0	09·18	0			28·09	0
		07·26	0	5122·64	0	23·36	1
		05·50	0	5120·86	0	21·41	0
5401·28	1	01·48	2	5113·36	1	14·09	4
5399·24	0	99·56	2			09·25	1
		98·59	0			07·26	1
5394·36	0	95·15	0			03·58	3
5392·55	0	92·67	0			99·86	0
		91·51	0			96·38	0
5388·35	3	88·53	6			95·00	0
		87·05	2			90·34	0
5372·07	0	73·59	2	5085·03*	1	85·36	5
5366·20	0	66·00	3			81·80	4
5356·13	0	56·78	0	5080·73	0	80·63	4
5344·01	0	44·07	0	5075·62	0	75·70	2
5343·43	0					72·62	1
5336·69	1	36·77	3			70·33	1
5334·46	0	32·04	0	5068·24	1	68·26	5
		22·26	0	5064·08	0	64·12	5

* Ames, 5084·9.

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.
5061·92	0	62·02	2	4883·97	0	84·04	1
5055·25*	1	55·02	7	4878·30	0	78·06	0
		49·53	2	4876·09*	2	76·13	4
		47·91	2	4874·41	0		
5044·03	0			4873·20	3	73·30	4
		41·71	4	4869·58	1	69·68	0
5040·00	0	39·74	4	4867·16	1	67·24	0
5030·56	0	30·40	4	4861·50*	10	61·60	
		20·60	0	4860·28	0		
5016·53	1	16·67	4	4858·91	0		
5015·27	2	14·93	6	4856·73	4	56·77	2
5013·23*	4	13·01	7	4849·47	4	49·57	4
5011·48	1	11·56	1	4843·65	1d	43·67	1
5008·24	1	08·34	4			42·45	1
5003·57	2	03·50	5	4838·39*	2	38·31	3
		98·06	2	4832·93	1		
		96·60	2	4831·73	0		
		90·43	1	4830·91	0		
		89·54	0	4824·67	1		
		83·44	0	4823·10	2	23·20	2
4980·55	1	80·52	4	4817·71	1d		
		79·06	0	4813·76	2	13·93	2
		78·14	0	4807·49	1		
		76·50	0	4802·14	0		
4973·43*	3	73·41	6	4797·90*	3	97·81	4
4969·35	0	69·44	3	4797·14	2	97·08	2
4966·98	1	67·13	4	4794·11	1	93·97	2
		61·42	0	4791·02	0	90·93	1
4956·90	0	57·02	4	4789·58	1	89·41	1
4955·94	0	55·92	4	4786·23	1	86·00	1
		53·03	0	4785·03	1	84·74	1
4945·07	0	45·21	0			82·68	0
		42·67	0	4781·12	2	80·77	2
4939·90	0	39·82	2	4777·59	2	77·36	2
4939·23	0					73·92	0
4935·29	0	36·70	0	4770·87	0	70·56	0
4934·43	4	34·44	8	4768·35	0		
4933·68	1			4767·43	0		
4932·45	1	32·40	2	4763·96*	3	63·53	3
4928·88*	5	28·85	8	4758·72	0		
		25·74	1	4756·89	1		
4924·20	0	24·48	0	4755·42	0		
4919·30	0	19·32	2	4751·72	0		
4909·00	1	09·06	2	4743·56	1	43·53	1
4906·39	1	06·40	2	4742·90	1	42·86	1
4901·99	0	01·90	0	4742·19	0		
4901·03	0	01·14	0	4741·14	1	41·31	0
4896·69	0	96·55	2	4732·96	0		
4891·44	1	91·36	2	4730·87	1		
4888·77	0	88·58	0	4729·13	0		
4886·62	0	86·35	1	4725·00	2		

* Ames, 5055·2, 5013·15, 4973·3, 4928·8, 4876·1, 4861·49, 4838·3, 4797·9, 4764·0.

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Frost.	Wave-length.	Intensity.	Hasselberg.	Intensity.	Frost.
4723·17	6	23·23	4	23·16	4585·21	0			
4721·76	0	21·33	0		4584·71	1			
4719·18*	6	19·23	5	19·11	4584·02	0			
4714·10	2	14·04	2		4582·79	6	82·83	4	82·78
4711·17	1	11·23	0		4581·76	2	81·63	0	81·75
4709·68	3	09·62	3		4580·19*	7	80·24	4	80·21
4708·70	0				4579·60	1			79·70
4705·42	0				4578·22	2	77·92	2	78·22
4702·73	1	02·53	0		4576·07	3	75·60	3	76·08
4692·18	1	92·12	1		4572·90	5	72·54	6	72·94
4690·30	3	90·29	2	90·29	4568·30	7	68·01	6	68·35
4686·94	2	86·87	1		4565·80	0	65·18	0	
4686·26	1	86·37	1		4563·88	1	63·66	2	63·96
4684·79	1	84·57	0		4562·41	2	62·21	2	62·45
4683·96*	4	83·90	4	83·97	4561·28	0			
4682·48	2	82·56	2		4560·40	0			
4681·56	0				4558·69	2 <i>d</i>	58·65	2 <i>d</i>	58·75 <i>d</i>
4680·57	1	80·50	2		4557·43	2 <i>d</i>	57·27	2	57·46
4679·26	2	79·20	1	79·29	4554·34	3	54·13	4	54·28
4675·41	0	75·48	2		4552·58	0			
4674·62	1	74·92	2		4551·84	0			
4673·26	1	73·41	0		4551·14	2	51·03	2	51·15
4671·46	2	71·66	2	71·47	4550·10	1	49·77	0	50·31
4670·79	1				4548·13	1	47·89	0	
4670·14	0				4547·37	0			
4669·39	1				4543·87	2	43·67	1	43·89
4667·90	1	67·90	0		4541·20	0			
4667·23	1				4539·35	2	39·19	1	39·30
4665·73	2	65·80	2		4538·51	0			38·43
4662·94	4	63·15	3	62·95	4537·91	0	37·85	1	
4661·55	3	61·64	2	61·64	4536·00	0			
4660·54	2	60·48	1	60·57	4534·80*	2	34·52	4	34·61 <i>d</i>
4658·97	0				4534·33	2			
4658·02	0				4533·28	2	32·86	1	33·30
4654·16	1				4532·13	0			32·18
4653·18	4	53·16	3	53·18	4531·35	0			
4650·60	0				4529·26	2	28·87	2	29·37
4649·51	0				4527·81	0			
4648·74	0				4527·27	0			
4645·48	1	45·20	0	45·51	4524·31	2	23·82	2	24·29
4634·77	3	34·40	0	34·77	4523·37	0	23·07	0	
4634·20*	9	33·90	7	34·21	4521·63	1	21·20	0	21·62
4632·06	6	31·48	6	32·02 <i>d</i>	4520·11	0			20·17
4631·62	3				4519·27	0			
4628·15	6	27·66	5	28·17	4517·62	1			
4625·53	2	25·14	3	25·53	4515·69	0	15·63	0	15·71
4620·90	0	20·74	0		4515·32	0			
4618·45	3	18·34	4	18·47	4514·51	0			14·48
4617·69	3	17·59	4		4513·96	0			
4614·72	0				4512·99	0			
4613·19	0				4511·89	2			
4607·56	2	07·44	1	07·58	4511·11	2	10·65	0	10·98
4605·54	1				4509·29	0			09·12
4598·68	1			98·73					07·05
4597·35	1				4505·80	3	05·68	0	05·80
4592·01	1								05·16
4590·06	0				4504·70	0			
4588·85	1				4503·99	0			03·96

* Ames, 4719·2, 4683·95, 4634·15, 4580·1, 4534·8.

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Frost.	Wave-length.	Intensity.	Hasselberg.	Intensity.	Frost.
4502·84	0				4443·08	0	43·93	0	
4502·11	3	01·83	0	02·17	4441·58	0	41·42	0	
4500·21	0				4438·61	0			
4499·63	0								37·77
4498·75	1			98·69	4436·17	0			
4498·27*	4	98·15†	4	98·25	4435·11	0			
		96·81	0	95·57	4434·43	0			
		95·12	0		4432·52	0			
4493·86	1	93·43	1	93·84	4431·61	0			
4490·62	5	90·35	4	90·65	4426·11	1	25·91	0	26·13
		89·19	0		4425·33	1			
4488·00	3	87·71	3	88·01	4423·38	1d	23·35	0	23·43
4486·22	3	85·87	3	86·21			22·75	0	22·86
4482·25	1	81·85	0	82·19	4421·23	0			
4481·44	0				4420·48	1	20·27	0	
4479·77	0	80·04	0		4419·66	1	19·44	0	
4479·18	1	78·65	0		4417·48	2	17·40	3	17·49
4477·27	2	76·95	1	77·24	4416·53	0			16·43
		75·75	0		4415·25	1			15·16
4474·42	3	74·11	2	74·42	4414·39	1			14·43
4472·18	1	71·68	0		4413·66	1			13·70
4471·70	1				4412·42*	3	12·37	5	12·47
4468·36	0				4410·75	1	10·56	1	
4467·30	3	66·93	2	67·33	4404·80	0			
4464·34	1d	63·80	0	64·19	4401·77	0			01·79
4461·14*	6	60·78	4	61·15	4400·89	1	00·92	2	00·94
4459·02	1	58·85	0	58·97	4398·30	0			98·28
4456·95	2d	56·80	2	56·91					93·02
4455·93	1	55·57	1		4392·07	0d			91·90
		54·36	0		4391·11	1	91·04	2	91·13
4453·24	1d	52·94	0	53·22	4389·26	1	89·23	1	
4450·99	1	50·81	0				87·56	0	86·41
4450·07	1	49·83	1	50·11	4384·56	0			
4448·20	1				4383·62	0			
4447·73*	4	47·65	4	47·77	4381·68	0			
4445·42	3	45·31	2	45·44	4379·59	1	79·37	2	
4444·42	1	44·24	0		4367·96	0			

Wave-length.	Intensity.	Hasselberg.	Intensity.	Ames.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.	Ames.	Intensity.
4342·07	4					4311·90	0				
4340·60	6	40·66	10	40·66	15	4308·78	0				
		38·90	4			4306·41	1				
4335·70	1					4306·00	0				
4332·74	1					4304·09	1				
4330·41	0					4303·60	1				
4329·84	0					4295·67	0				
4328·07	0					4279·53	0				
4318·35	0					4253·48	1				
4313·16	0					4246·85	0				

* Ames, 4498·75, 4461·1, 4447·85, 4412·35.

† These and the succeeding values were the result of photographic observation.

Table I—*continued.*

Wave-length.	Intensity.	Hasselberg.	Intensity.	Ames.	Intensity.	Wave-length.	Intensity.	Hasselberg.	Intensity.	Ames.	Intensity.
4243·55	2	43·33	2			4123·90	0				
4237·61	0	36·52	2			4113·74	1				
4234·03	1	33·86	2			4111·12	1 <i>d</i>				
4233·59	2	33·48	2			4110·24	1	10·23	0		
4232·85	1 <i>d</i>	32·72	0			4109·47	1	09·36	0		
4231·23	1					4108·08	1 <i>d</i>	08·14	0		
4228·94	0							07·87	0		
4227·55	2	27·43	0			4106·39	2	06·35	0		
4224·68	2	24·49	0			4101·89	3	01·98	15	01·85	10
4224·10	3	23·96	2			4097·61	2	97·58	1		
4222·70	2	22·56	4					96·64	0		
4222·32	2	22·22	4			4096·24	1	96·13	0		
4219·69	1					4095·61	1	95·59	0		
4216·33	0					4089·01	1				
4212·67	5	12·43	6	12·65	7	4087·91	4	87·89	3		
4210·29	3	11·87	0			4085·39	2	85·38	1		
		10·11	3			4084·15	0	83·08?	0		
4209·34	3	09·13	2			4082·53	3	82·55	1		
4208·57	0					4081·65	1	81·65	1		
4207·71	0					4079·03	3	78·02*	8	79·0	5
4206·26	1	06·06	1			4074·25	2	74·28	0		
4205·26	8	04·99	10	05·2	8	4073·12	2	73·11	0		
4202·49	0					4071·39	2	71·42	1		
4201·15	1					4069·80	6	69·87	6	69·75	7
4199·95	3	99·79	5			4067·05	6	67·10	5	67·0	7
4198·34	1	98·28	2			4065·75	2	65·39	0		
4195·82	3	95·58	5	95·9	6	4063·78	3	63·87	2		
4194·33	0					4062·64	6	62·77	4	62·6	6
4189·59	1					4059·47	0				
4188·42	0					4057·71	0				
4182·33	4	82·12	4			4056·55	1				
4180·30	3	80·09	4			4055·46	1				
4179·70	2	79·58	2			4051·43	0				
4177·91	2	77·71	3			4048·58	2				
4177·26	6	77·07	10	77·25	8	4043·71	3				
4175·33	3	75·11	4			4038·67	0				
4171·45	4	71·26	6	71·35	7	4035·73	1				
4168·80	0					4034·22	0				
4167·72	0	67·57	0			4031·90	0 <i>d</i>				
4165·29	1	65·29	1			4028·46	3				
4163·67	2	63·70	1			4027·50	0				
4162·09	2	62·05	3			4026·76	0 <i>d</i>				
4159·49	1	59·38	2			4024·86	1				
4156·86	2 <i>d</i>	56·62	4			4021·89	0 <i>d</i>				
4155·93	0					4019·07	0				
4152·84	0					4009·70	0				
4151·79	0					4008·95	0				
4146·38	1	46·08	0			4006·10	2				
4145·77	1	45·47	0			4005·57	2				
4139·84	0					4002·60	1				
4134·14	1					4000·99	1				
4132·15	1					4000·29	1				
4131·59	1										

* Hasselberg's line due to Hg 4077·99.

Table I—*continued.*

Wave-length.	Intensity.	Ames.	Intensity.	Wave-length.	Intensity.	Ames.	Intensity.
3997·28	3	97·25	4	3865·62	0		
3993·95	1			3864·34	1		
3993·36	1			3863·35	2	63·3	5
3992·00	3	92·0	4	3861·69	2	61·7	4½
3991·23	1			3860·87	1		
3990·17	3	90·15	6	3860·05	1		
3987·06	1	87·0	3	3858·89	1d	58·85	4
3982·73	1	82·75	4	3857·89	1		
3978·94	0			3851·41	1		
3978·27	0			3849·45	0		
3977·03	0d			3836·59	1	36·6	3
3975·80	1					35·6	?
3974·90	0			3812·90	0		
3974·30	1			3809·18	0		
3971·58	0					04·9	6
3970·21	1	70·25	8	3803·17	3	03·2	4
3963·81	0			3800·28	0		
3963·21	1	63·3	3	3799·20	1		
3962·48	1	62·4	2	3798·05	0	98·0	?
3960·24	0			3797·63	1	97·7	4
3955·36	0			3796·73	2	96·8	5
3951·63	0			3794·67	1		
3950·72	0			3791·58	0		
3947·36	0			3784·30	0		
3944·45	1	44·5	3	3777·22	0		
3933·90	0			3774·40	0		
3928·50	0			3771·64	1	71·7	3
3927·32	0					70·7	0
3924·57	2	24·5	3			70·3	2
3918·11	0			3754·77	0		
3917·13	0			3751·98	1	52·05	0
3910·29	0			3741·40	0	41·3	2
3907·68	0					34·15	0
3906·51	2			3732·25	1	32·2	3
3902·76	0			3722·27	0d	22·2	2
3889·55	1	89·3	4			21·8	0
3889·16	2d	89·15	7			16·05	1
3888·00	1					11·9	?
3886·42	0			3702·21	2	02·2	3
3884·32	1			3700·20	0d		
3882·19	0			3690·29	1		
3879·73	1	79·7	3	3684·45	4	84·3	5
3878·79	0d			3682·20	1d	82·05	4
3878·08	0			3678·20	0		
3877·48	0			3676·97	0		
3874·95	0			3674·52	3	74·5	5
3874·27	1			3673·78	1		
3872·54	2	72·45	4	3666·02	1		
3871·75	3	71·8	5	3665·26	0		
3870·98	1d			3664·24	1		
3870·09	1			3652·58	0		
3869·33	1					44·8	1
3868·20	0					33·5	2
3867·29	1	67·2	4				

204 *Wave-lengths in the Secondary Spectrum of Hydrogen.*

Table I—*continued.*

Wave-length.	Intensity.	Living and Dewar.	Intensity.	Wave-length.	Intensity.	Living and Dewar.	Intensity.
3520·60	1			3091·29	1	90·6	
3472·65	0	71·9		3090·36	1	89·8	
3395·04	1			3089·76	2	89·3	
3368·64	0			3087·33	0 <i>d</i>	86·7	
3295·49	0	95·5		3085·25	0	84·6	
3154·47	0 <i>d</i>	54·0		3083·23	1	82·6	
3130·44	0	29·9		3081·56	2	81·0	
3129·42	0			3079·90	1	79·3	
3127·67	0	27·8		3078·43	1	77·9	
3124·90	1	24·5		2977·23	0		
3124·00	0	23·5		2974·42	1 <i>d</i>		
3122·49	1	22·2		2972·78	1 <i>d</i>		
3121·71	0	21·3		2971·20	0 <i>d</i>		
3119·73	1	19·2		2968·44	1		
3117·70	1	17·4		2830·15	1		
3117·26	0	16·6		2828·67	1		
3113·37	0	12·8		2827·23	1		
3112·09	0	11·5		2824·76	1		
3109·20	0	08·8		2804·56	1		
3102·30	0	01·6		2698·97	2		
3100·97	0	00·6		2661·77	0		
3099·40	0	99·0		2660·39	0		
3096·20	1	95·8		2639·90	0		
3095·38	0	94·8		2483·95	0		
3094·60	0	94·2		2482·87	0		
3092·81	0	92·0					

Table II.—Wave-lengths of the Mercury Lines seen in the Spectrum.

Wave-length.	Intensity.	Wave-length.	Intensity.	Wave-length.	Intensity.	Wave-length.	Intensity.
5790·86	8	3663·40	5	3021·62	6	2652·16	3
5769·80	7	3654·96	6	2967·42	7	2576·39	0
5460·93	10	3650·28	9	2925·52	2	2536·62	1
4916·38	0	3341·66	4	2893·74	3	2534·89	3
4358·49	9	3131·94	9	2847·88	0	2482·13	2
4339·37	1	3131·65	2	2803·62	3	2399·54	0
4077·99	6	3125·77	7	2752·97	1		
4046·72	8	3027·64	2	2655·26	2		
3984·16	1	3023·61	4	2653·83	2		